**5. Drawings**

Fig 1:

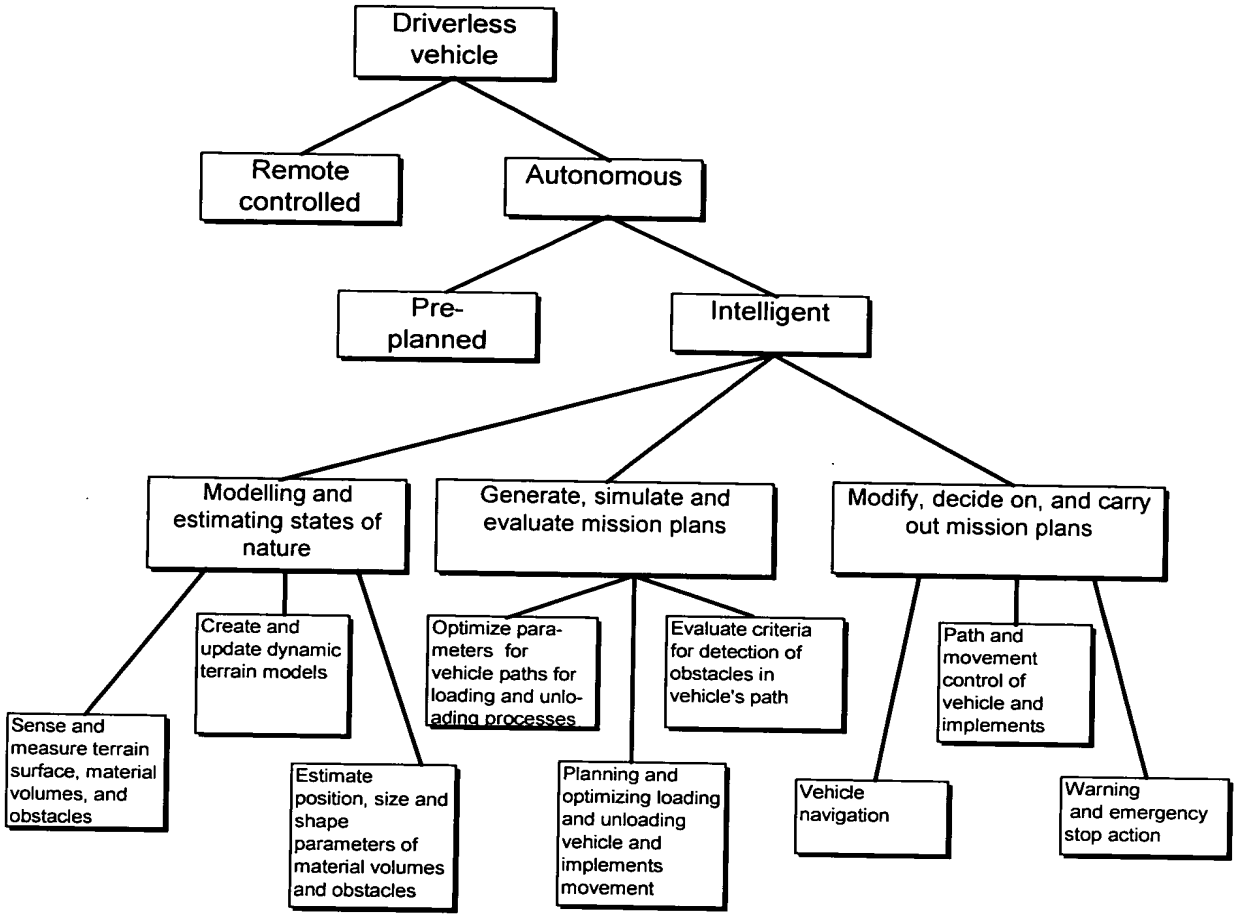



Fig 2:

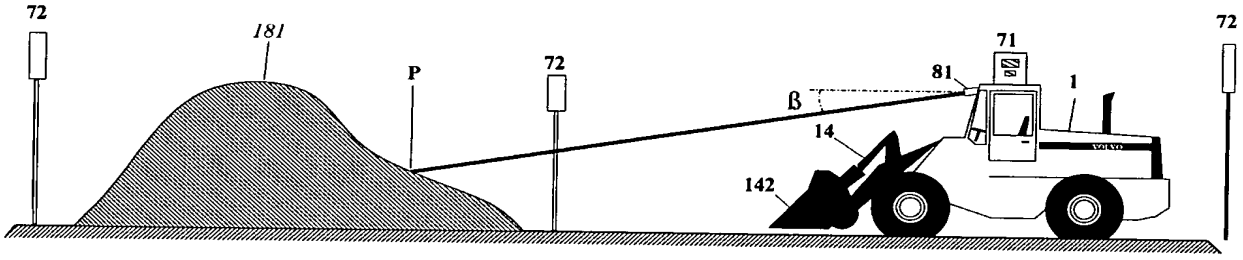


Fig 3:

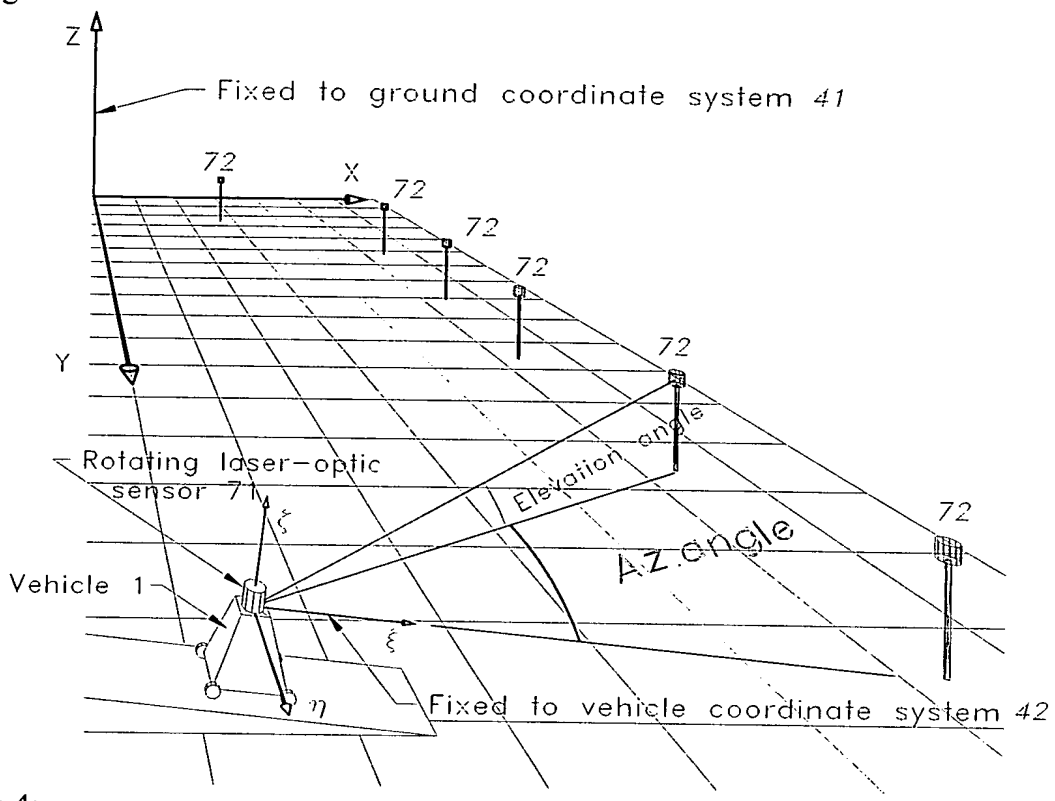

Z
Fixed to ground coordinate system 41
72
X
72
72
72
72
Y
Rotating laser-optic sensor 71
Elevation angle
Az.angle
72
Vehicle 1
ξ
ξ
η
Fixed to vehicle coordinate system 42

Fig 4:

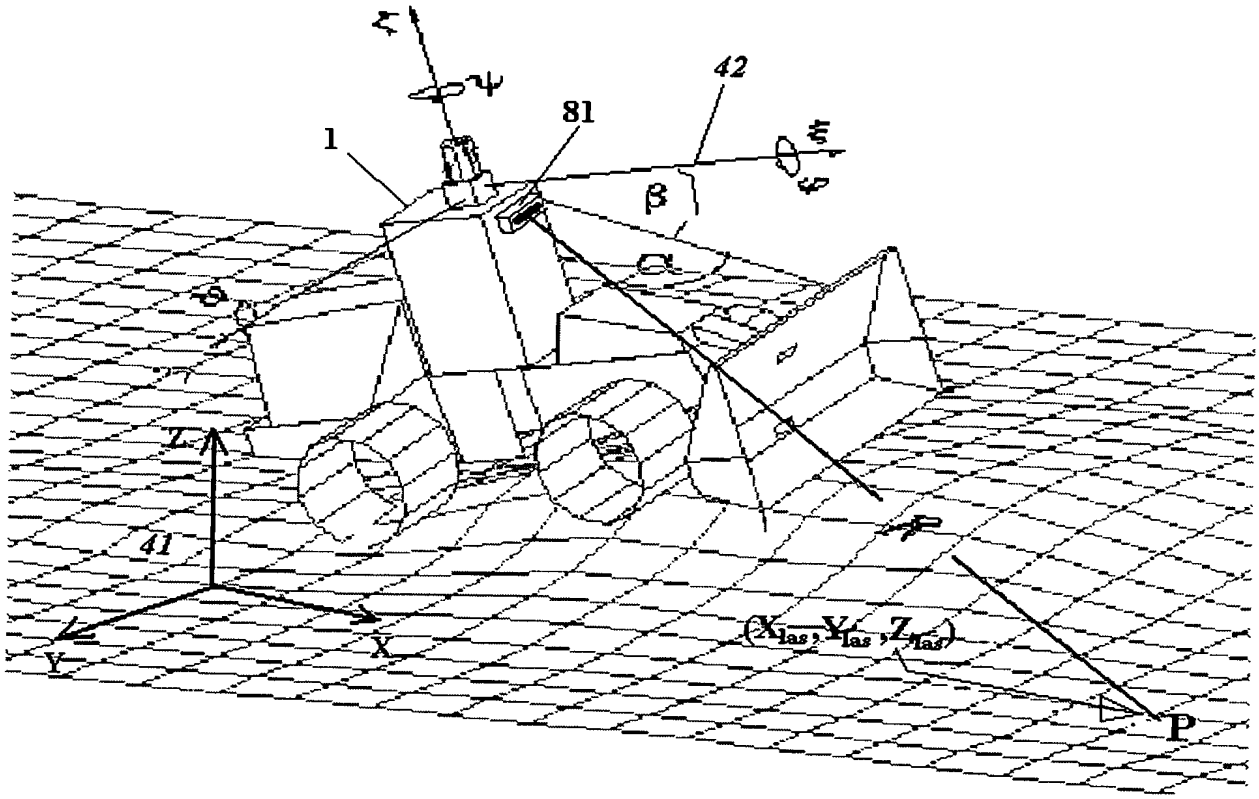

ζ
ψ
42
81
1
ξ
β
α
Z
41
Y
X
$(X_{las}, Y_{las}, Z_{las})$
P

Fig 5:

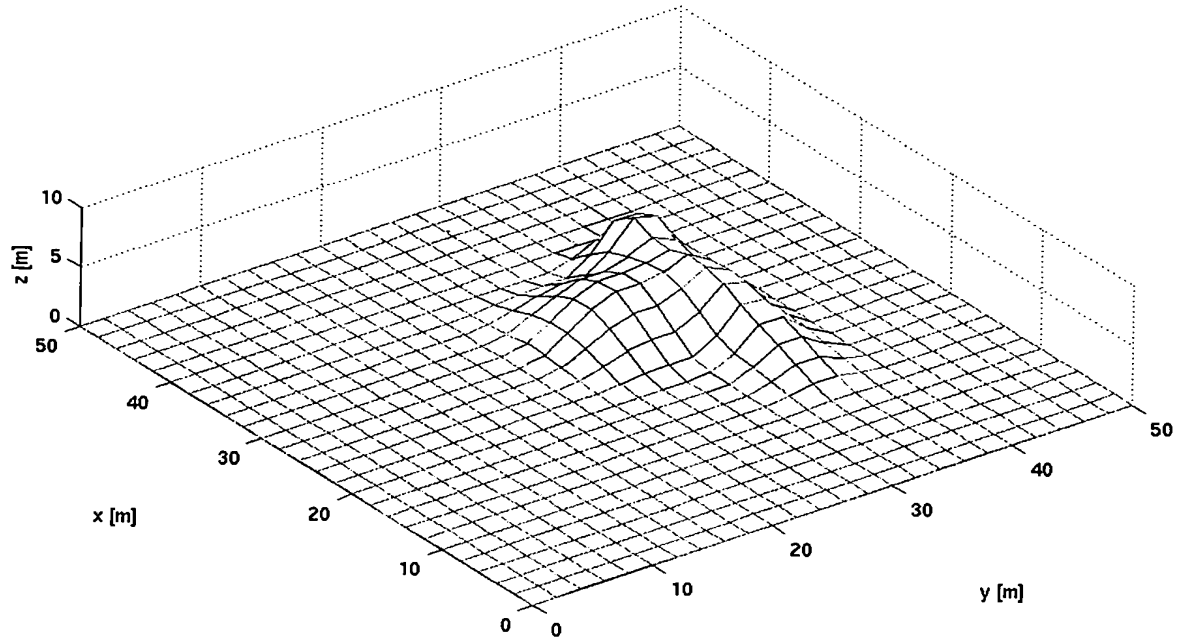

z [m]
10
5
0
50
40
30
20
10
0
x [m]
0
10
20
30
40
50
y [m]

Fig 6:

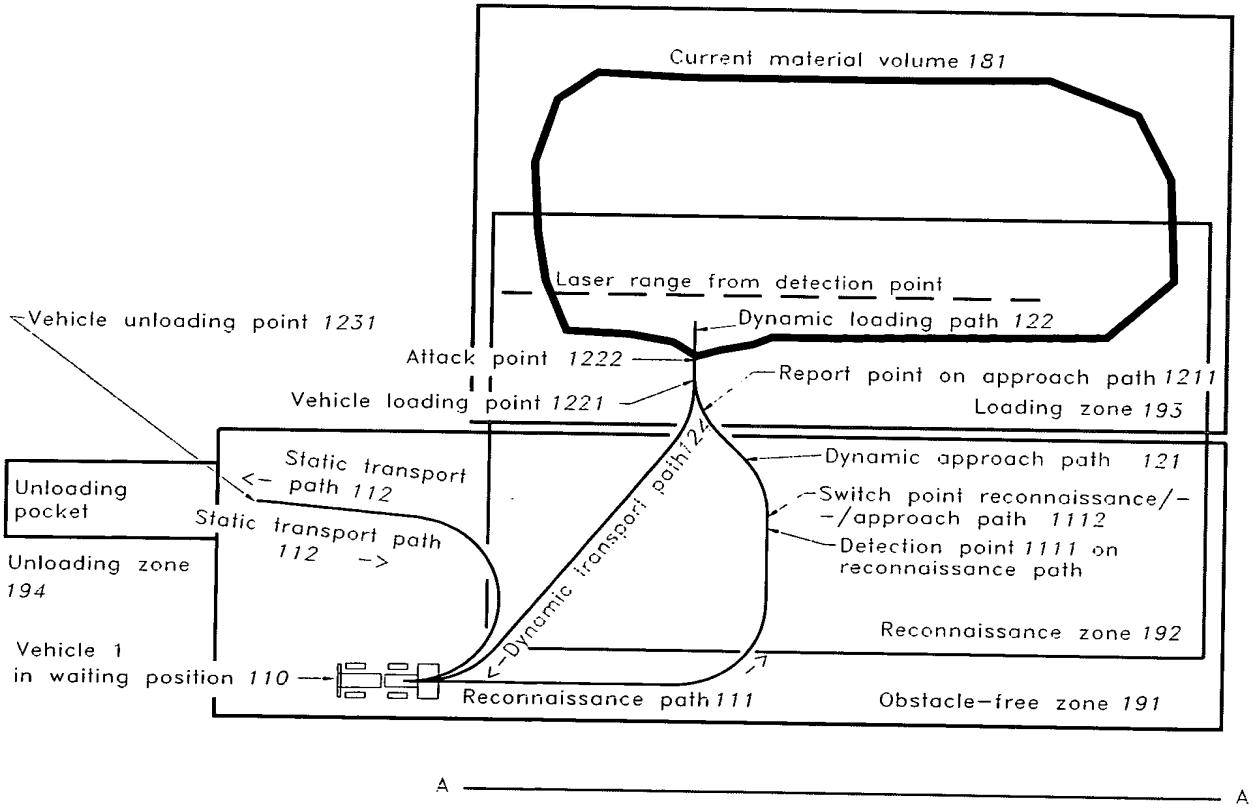

Current material volume 181
Laser range from detection point
Dynamic loading path 122
Vehicle unloading point 1231
Attack point 1222
Report point on approach path 1211
Vehicle loading point 1221
Loading zone 193
Static transport path 112
Dynamic approach path 121
Unloading pocket
Switch point reconnaissance/-/approach path 1112
Static transport path 112 ->
Detection point 1111 on reconnaissance path
Unloading zone 194
Dynamic transport path 124
Reconnaissance zone 192
Vehicle 1 in waiting position 110
Reconnaissance path 111
Obstacle-free zone 191
A
A

Fig 7:

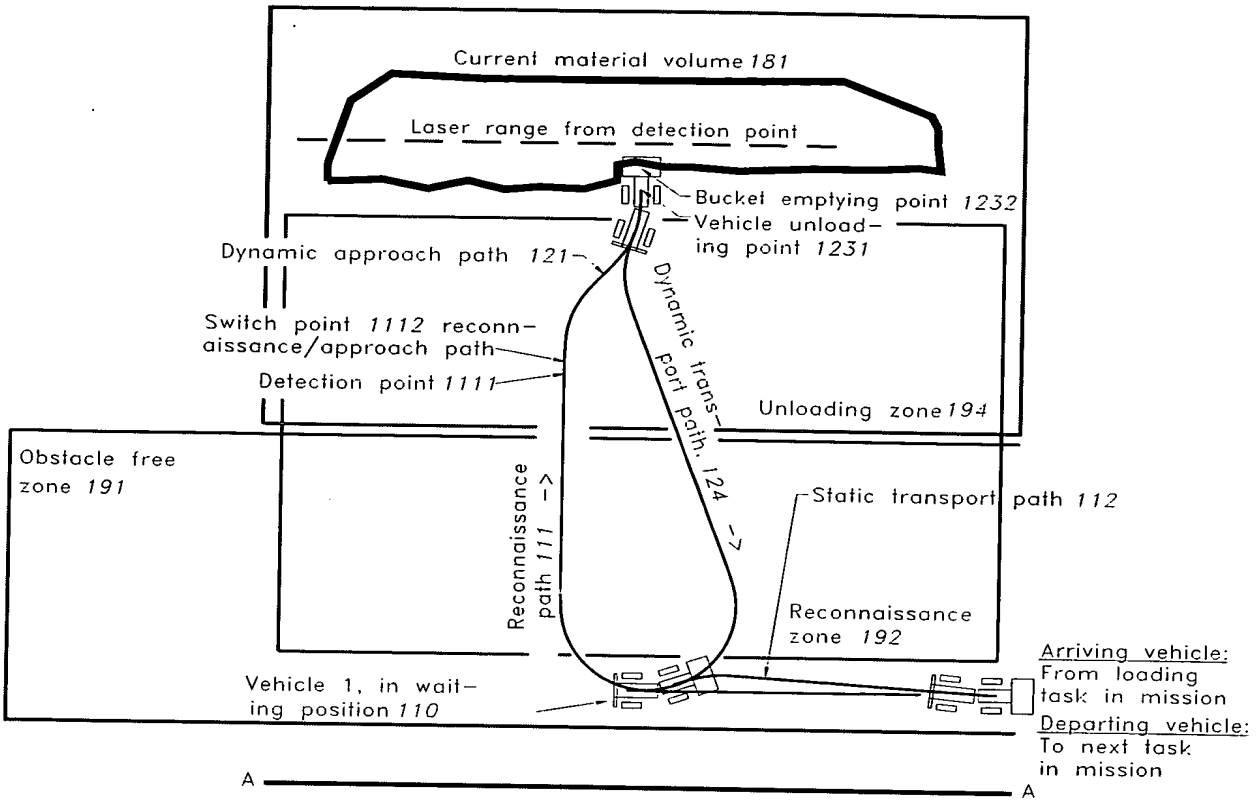

Current material volume 181
Laser range from detection point
Bucket emptying point 1232
Vehicle unloading point 1231
Dynamic approach path 121
Switch point 1112 reconnaissance/approach path
Detection point 1111
Dynamic transport path 124
Unloading zone 194
Obstacle free zone 191
Reconnaissance path 111
Static transport path 112
Reconnaissance zone 192
Vehicle 1, in waiting position 110
Arriving vehicle: From loading task in mission
Departing vehicle: To next task in mission
A
A

Fig 8:

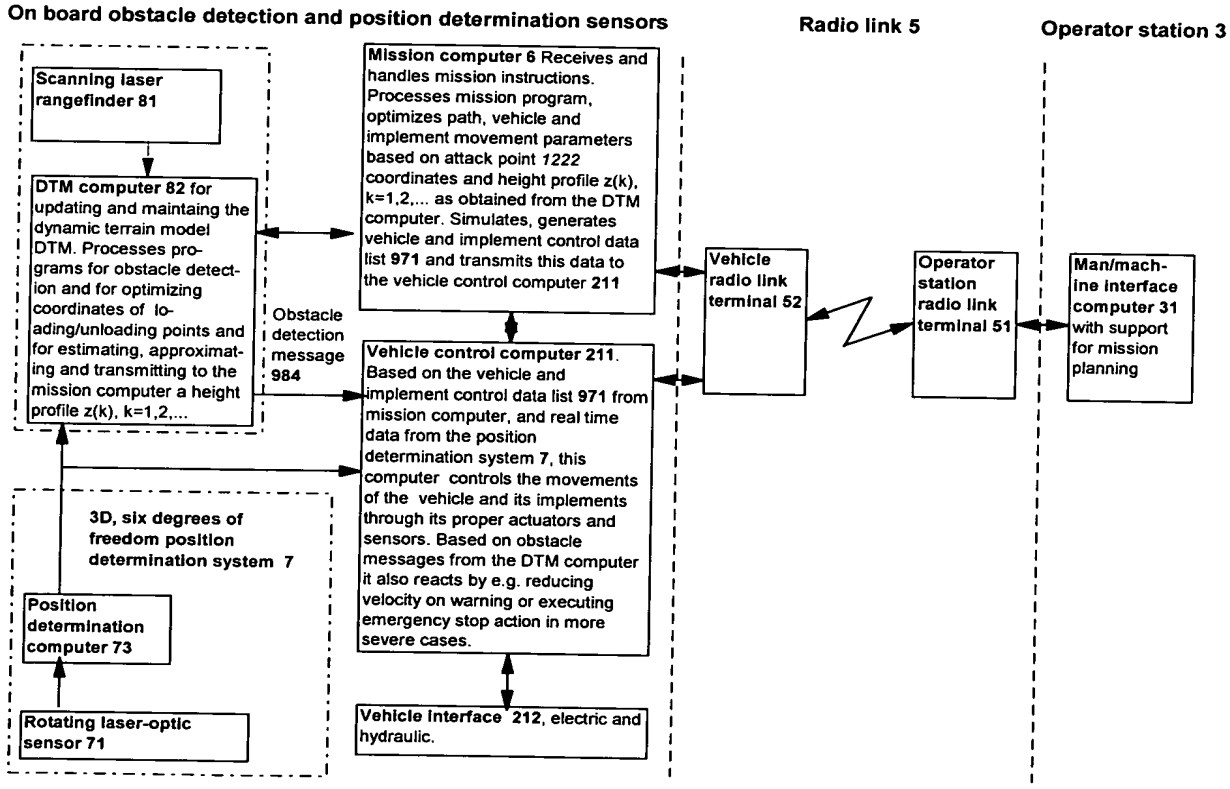

On board obstacle detection and position determination sensors
Radio link 5
Operator station 3
Scanning laser rangefinder 81
DTM computer 82 for updating and maintaing the dynamic terrain model DTM. Processes programs for obstacle detection and for optimizing coordinates of loading/unloading points and for estimating, approximating and transmitting to the mission computer a height profile z(k), k=1,2,...
Obstacle detection message 984
Mission computer 6 Receives and handles mission instructions. Processes mission program, optimizes path, vehicle and implement movement parameters based on attack point 1222 coordinates and height profile z(k), k=1,2,... as obtained from the DTM computer. Simulates, generates vehicle and implement control data list 971 and transmits this data to the vehicle control computer 211
Vehicle control computer 211. Based on the vehicle and implement control data list 971 from mission computer, and real time data from the position determination system 7, this computer controls the movements of the vehicle and its implements through its proper actuators and sensors. Based on obstacle messages from the DTM computer it also reacts by e.g. reducing velocity on warning or executing emergency stop action in more severe cases.
Vehicle interface 212, electric and hydraulic.
Vehicle radio link terminal 52
Operator station radio link terminal 51
Man/machine interface computer 31 with support for mission planning
3D, six degrees of freedom position determination system 7
Position determination computer 73
Rotating laser-optic sensor 71

Fig 9:

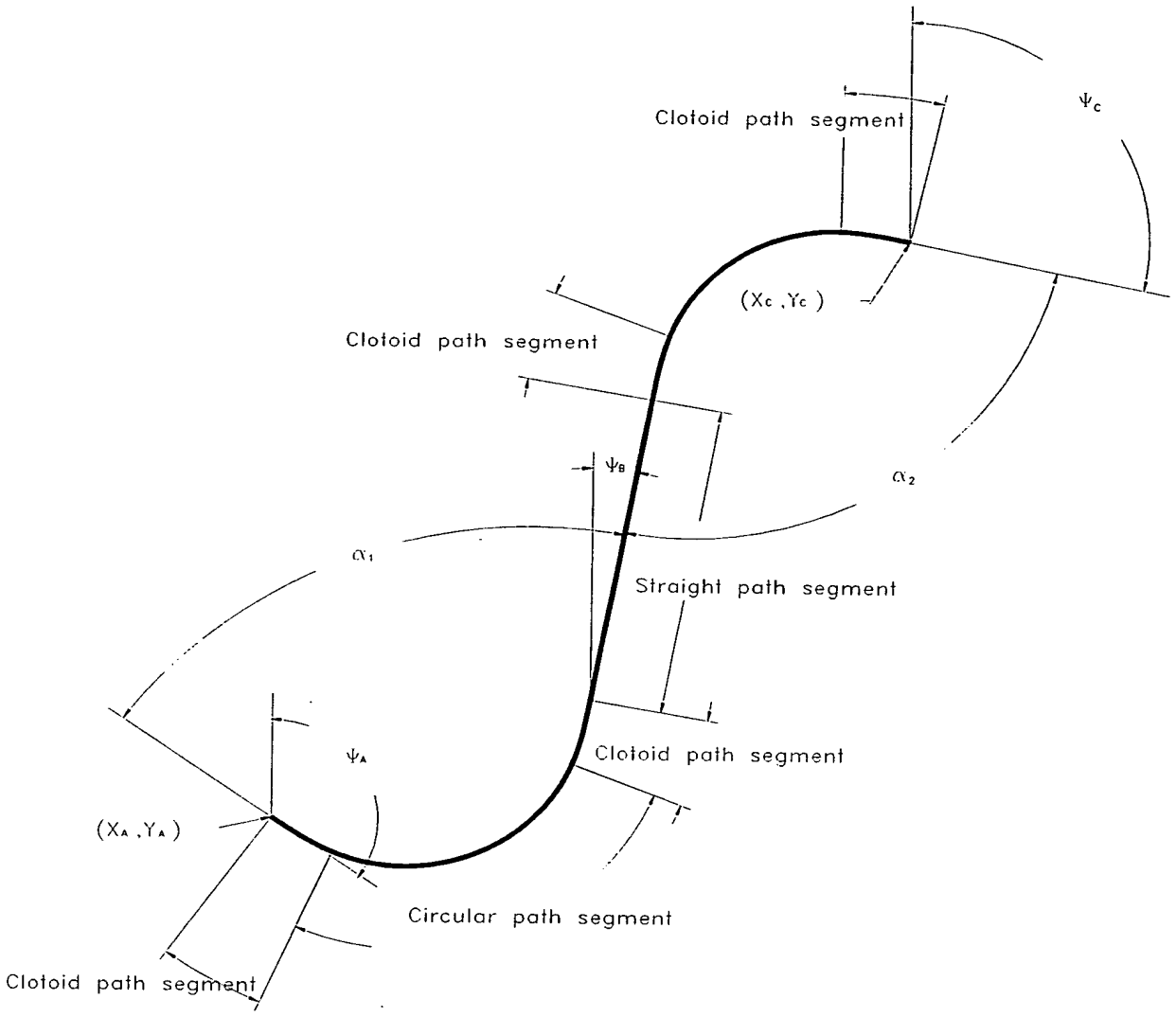

Clotoid path segment
$\Psi_C$
$(X_C, Y_C)$
Clotoid path segment
$\Psi_B$
$\alpha_2$
$\alpha_1$
Straight path segment
$\Psi_A$
Clotoid path segment
$(X_A, Y_A)$
Circular path segment
Clotoid path segment

Fig 10:

*Flow and exchange of mission instructions and lower level messages, in a reconnaissance and loading task*

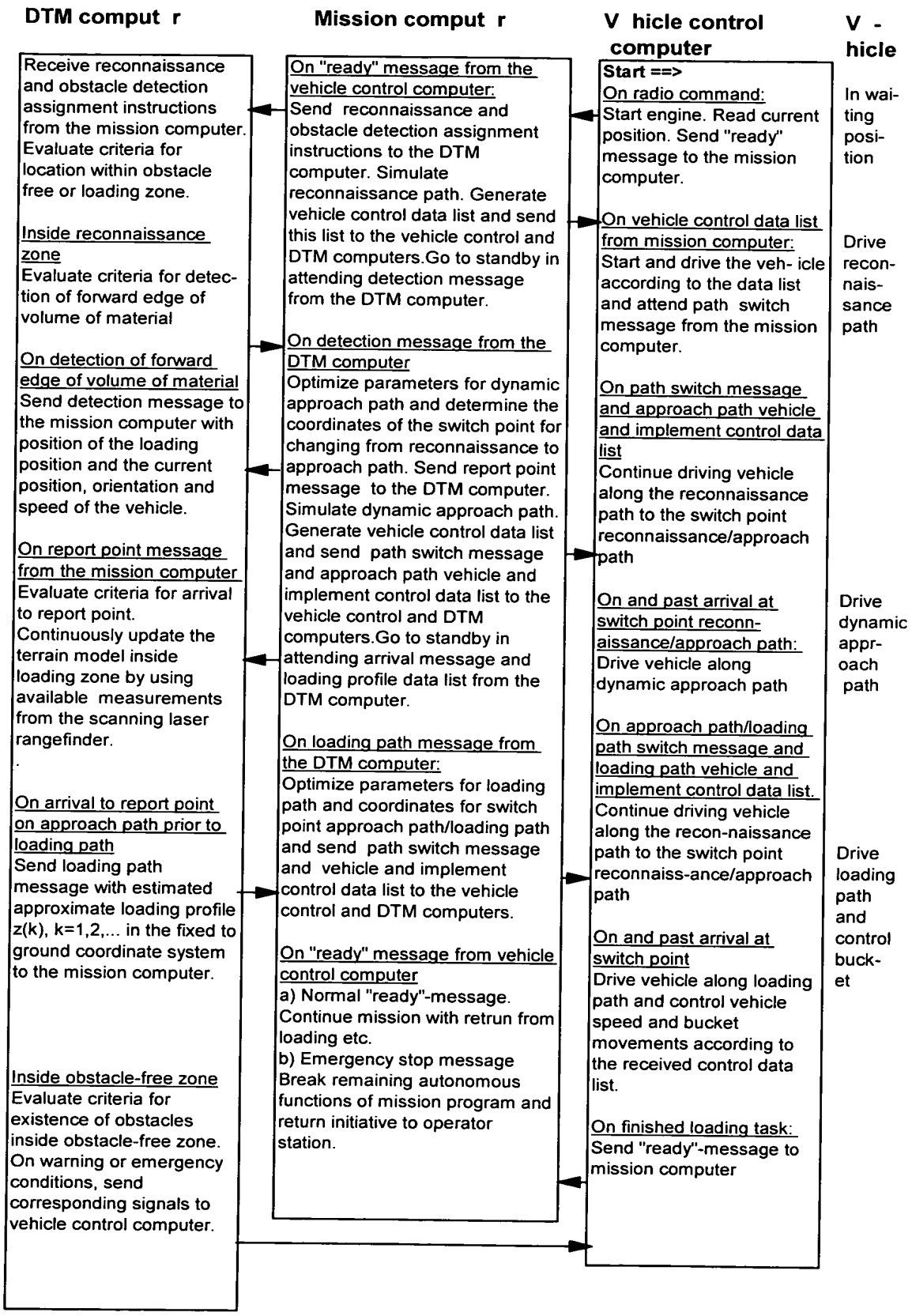


Fig 11:

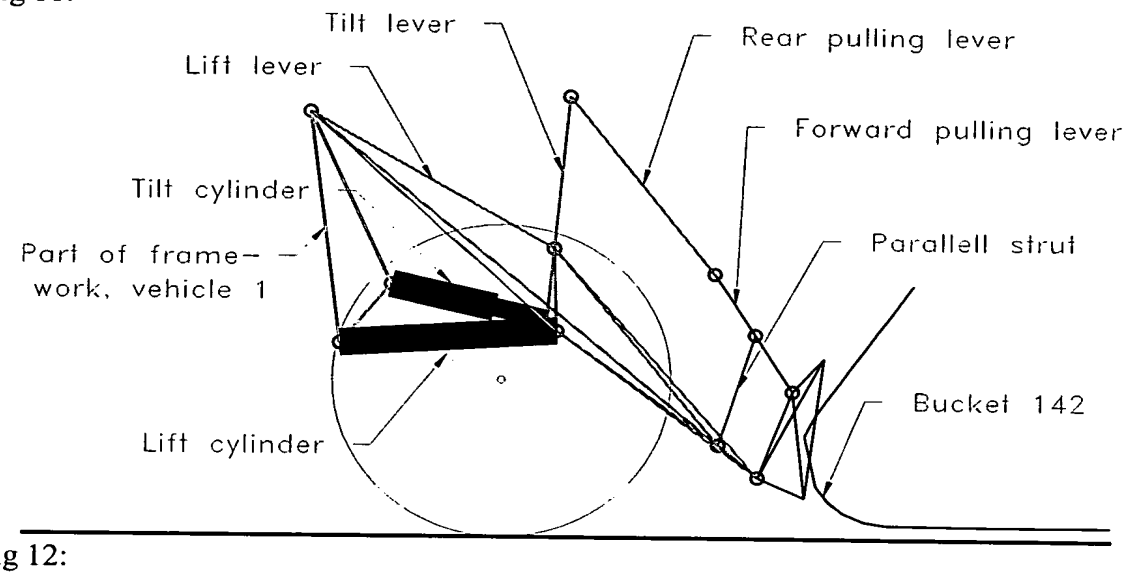



Fig 12:

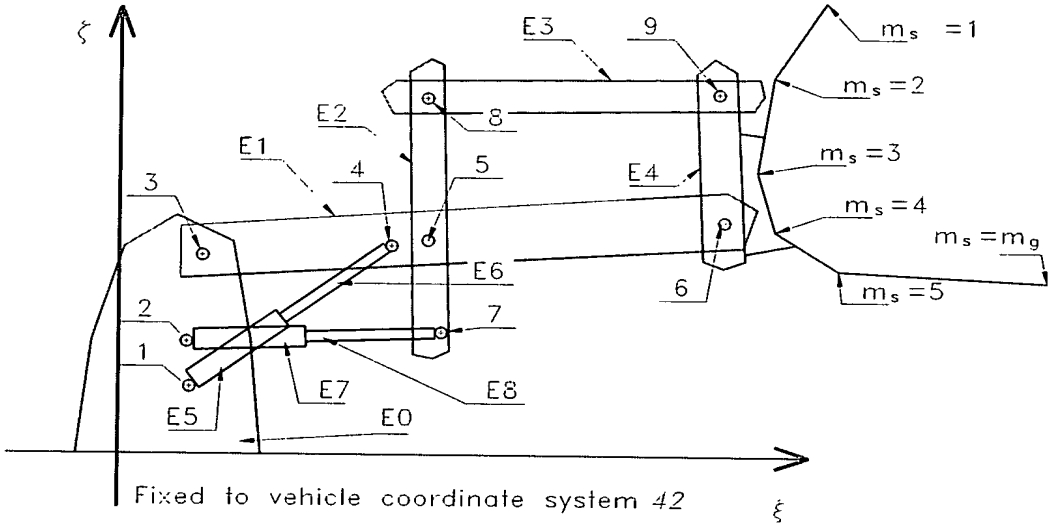



Fig 13:

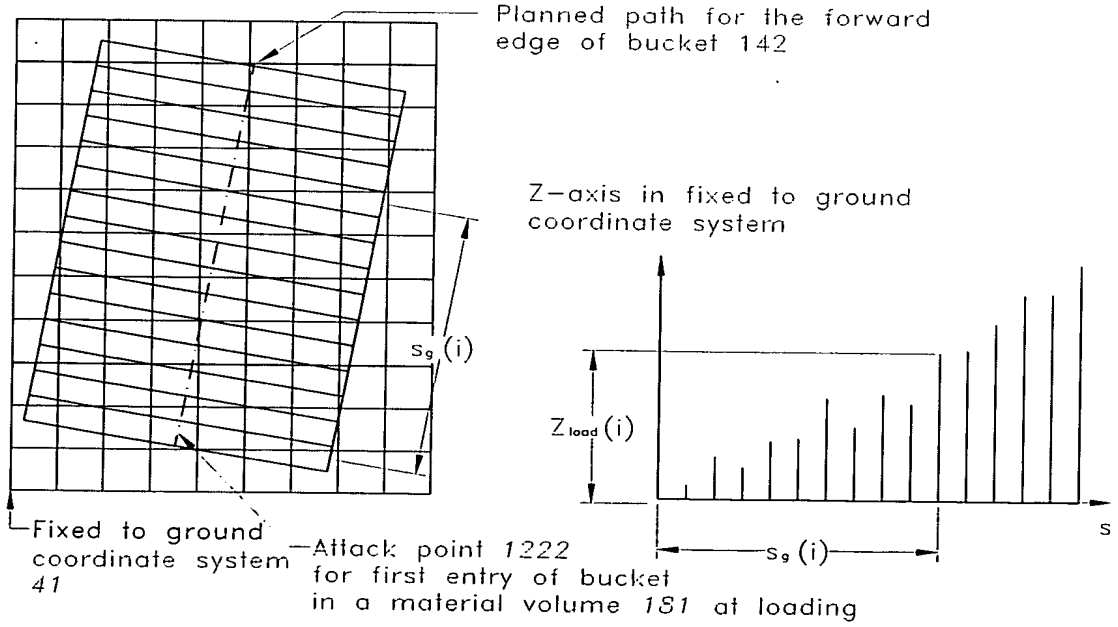


Fig 14:

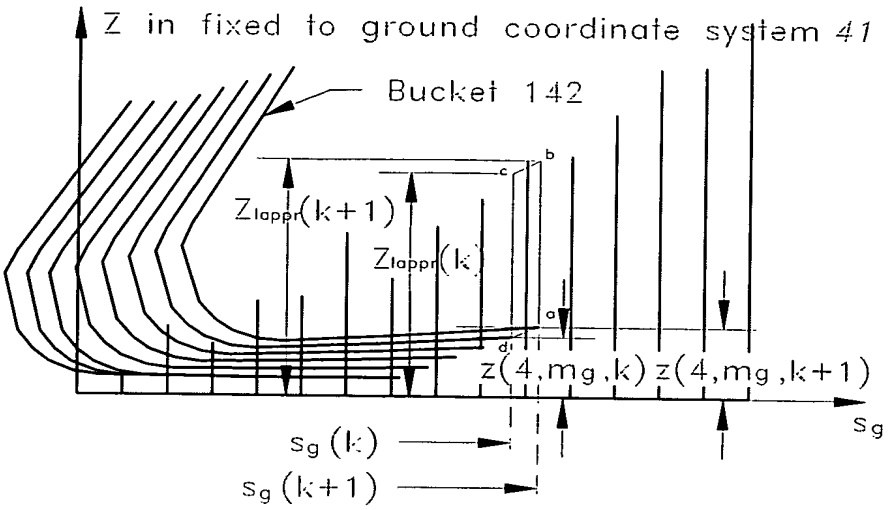



Fig 15:

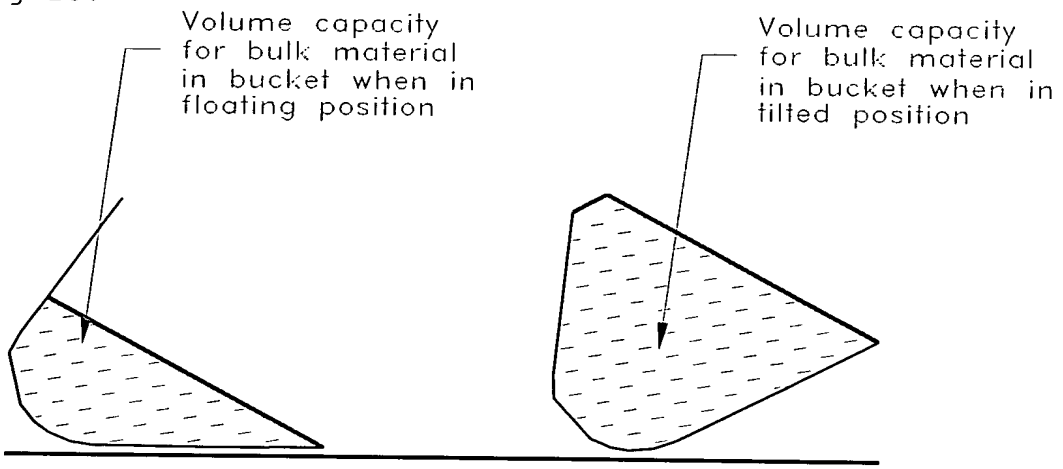



Fig 16:

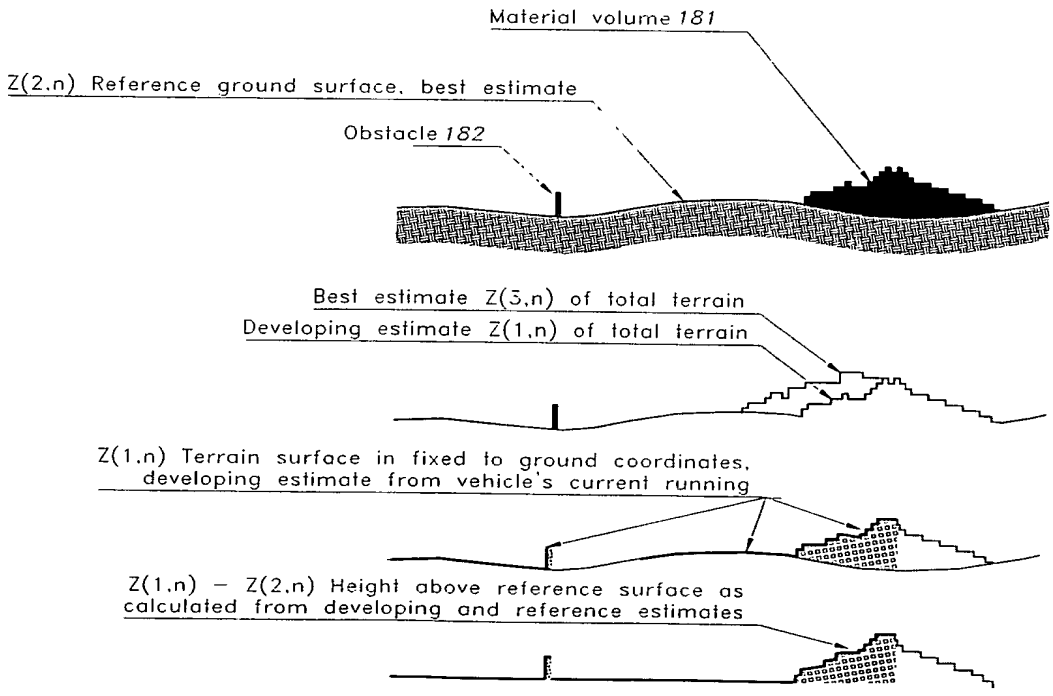
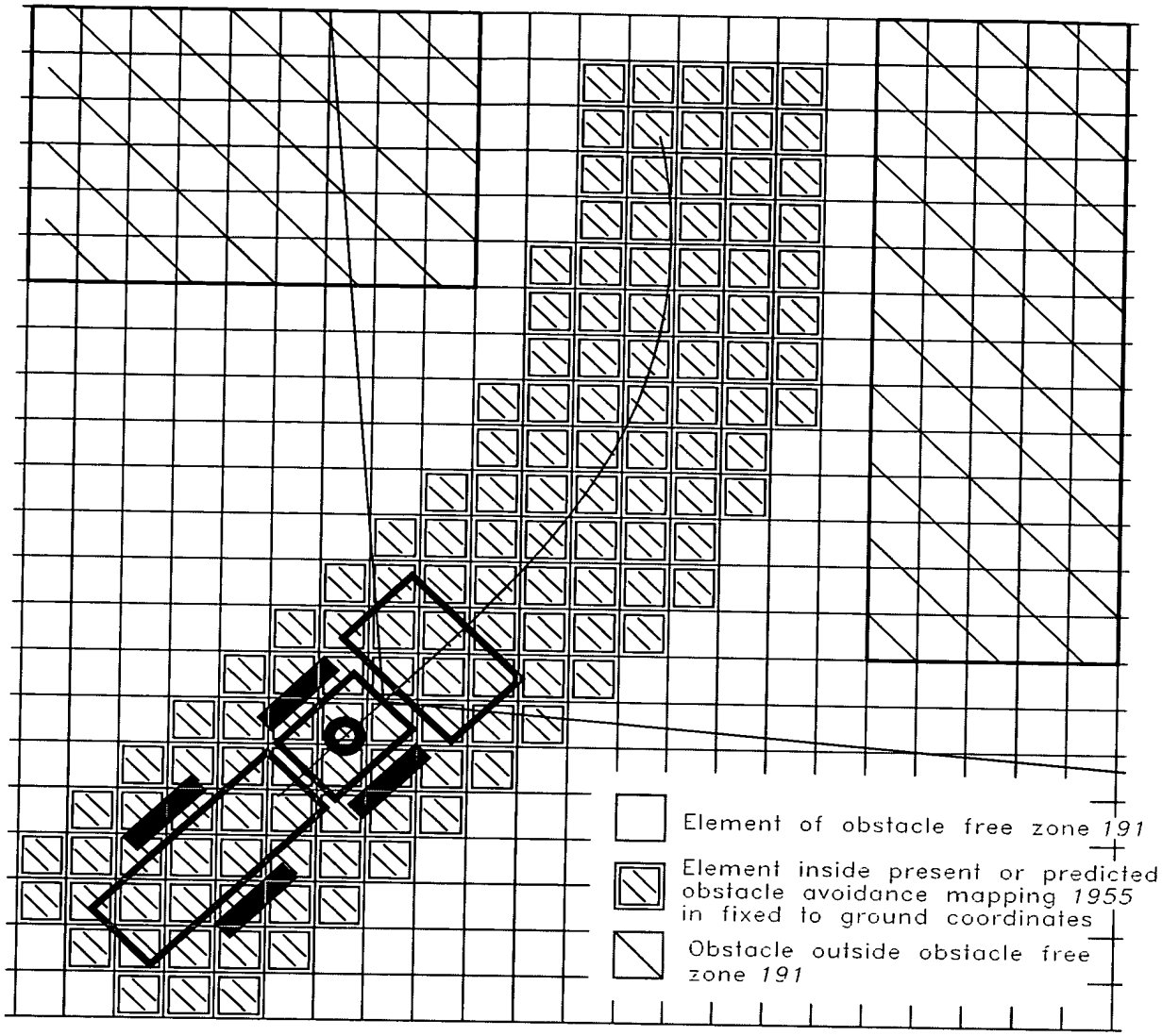


Fig 17:


Element of obstacle free zone 191
Element inside present or predicted obstacle avoidance mapping 1955 in fixed to ground coordinates
Obstacle outside obstacle free zone 191